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Physiology Lessons
for use with the
Biopac Student Lab MP41

Windows®
or Mac OS®

Lesson 1 ECG I

Electrocardiography

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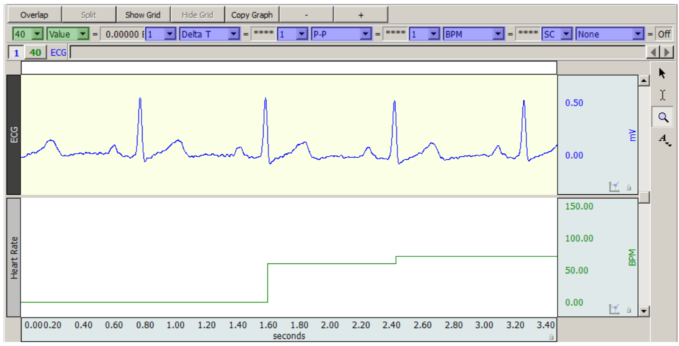
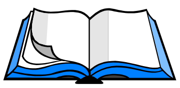


I. INTRODUCTION

The main function of the heart is to pump blood through two circuits:

1. **Pulmonary circuit**: through the lungs to oxygenate the blood and remove carbon dioxide, and
2. **Systemic circuit**: to deliver oxygen and nutrients to tissues and remove carbon dioxide.

Because the heart moves blood through two separate circuits, it is sometimes described as a dual pump.



In order to beat, the heart needs three types of cells:

1. Rhythm generators, which produce an electrical signal (SA node or normal pacemaker);
2. Conductors to spread the pacemaker signal; and
3. Contractile cells (myocardium) to mechanically pump blood.

The Electrical and Mechanical Sequence of a Heartbeat

The heart has specialized **pacemaker** cells that start the electrical sequence of **depolarization** and **repolarization**. This property of cardiac tissue is called **inherent rhythmicity** or **automaticity**. The electrical signal is generated by the **sinoatrial node (SA node)** and spreads to the ventricular muscle via particular conducting pathways: **internodal pathways** and **atrial fibers**, the **atrioventricular node (AV node,)** the **bundle of His**, the right and left **bundle branches**, and **Purkinje fibers** (Fig. 5.1).

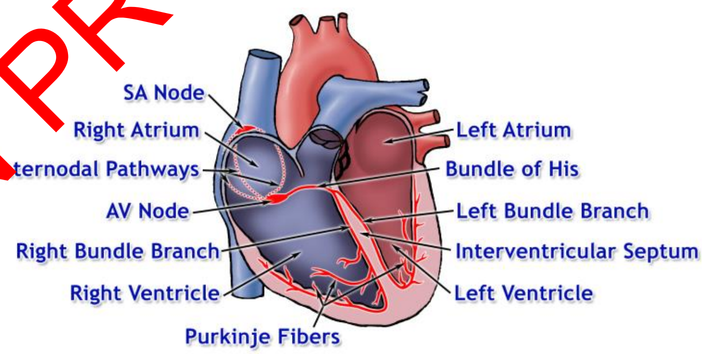


Fig. 5.1 The Heart

When the electrical signal of a depolarization reaches the contractile cells, they contract—a mechanical event called **systole**. When the repolarization signal reaches the myocardial cells, they relax—a mechanical event called **diastole**. Thus, the electrical signals cause the mechanical pumping action of the heart; mechanical events always follow the electrical events (Fig. 5.2).

The **SA node** is the normal pacemaker of the heart, initiating each electrical and mechanical cycle. When the SA node depolarizes, the electrical stimulus spreads through atrial muscle causing the muscle to contract. Thus, the SA node depolarization is followed by atrial contraction.

The SA node impulse also spreads to the **atrioventricular node (AV node)** via the **internodal fibers**. (The wave of depolarization does not spread to the ventricles right away because there is nonconducting tissue separating the atria and ventricles.) The electrical signal is delayed in the AV node for approximately 0.20 seconds when the atria contract, and then the signal is relayed to the **ventricles** via the **bundle of His, right** and **left bundle branches**, and **Purkinje fibers**. The Purkinje fibers relay the electrical impulse directly to ventricular muscle**,** stimulating the ventricles to **contract** (ventricular **systole**). During ventricular systole, ventricles begin to repolarize and then enter a period of diastole (Fig. 5.2).

Although the heart generates its own beat, the heart rate (beats per minute or BPM) and strength of contraction of the heart are modified by the **sympathetic** and **parasympathetic** divisions of the autonomic nervous system.

- The sympathetic division increases automaticity and excitability of the SA node, thereby increasing heart rate. It also increases conductivity of electrical impulses through the atrioventricular conduction system and increases the force of atrioventricular contraction. Sympathetic influence increases during inhalation.
- The parasympathetic division decreases automaticity and excitability of the SA node, thereby decreasing heart rate. It also decreases conductivity of electrical impulses through the atrioventricular conduction system and decreases the force of atrioventricular contraction. Parasympathetic influence increases during exhalation.

The Electrocardiogram (ECG)

Just as the electrical activity of the pacemaker is communicated to the cardiac muscle, “echoes” of the depolarization and repolarization of the heart are sent through the rest of the body. By placing a pair of very sensitive receivers (**electrodes**) on other parts of the body, the echoes of the heart’s electrical activity can be detected. The record of the electrical signal is called an **electrocardiogram (ECG).** You can infer the heart’s mechanical activity from the ECG. Electrical activity varies through the ECG cycle as shown below (Fig. 5.2):

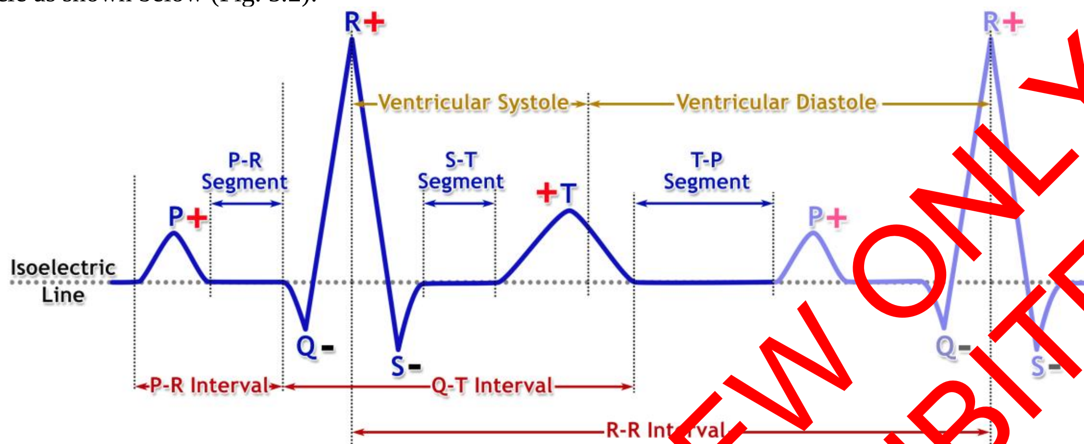


Fig. 5.2 Components of the ECG (Lead II) & Electrical and mechanical events of the cardiac cycle

The ECG represents electrical events of the cardiac cycle whereas Ventricular Systole and Ventricular Diastole represent mechanical events (contraction and relaxation of cardiac muscle, passive opening and closing of intracardiac valves, etc.). Electrical events occur quickly, mechanical events occur slowly. Generally, mechanical events follow the electrical events that initiate them. Thus, the beginning of ventricular diastole is preceded by the beginning of ventricular depolarization. In fact, in a normal resting Lead II, ventricular repolarization normally begins before the completion of ventricular systole in the same cardiac cycle. That is why the end of ventricular systole/beginning of ventricular diastole is marked in Fig. 5.2 about 1/3 of the way down the T-wave.

Because the ECG reflects the electrical activity, it is a useful “picture” of heart activity. If there are interruptions of the electrical signal generation or transmission, the ECG changes. These changes can be useful in diagnosing changes within the heart. During exercise, however, the position of the heart itself changes, so you cannot standardize or quantify the voltage changes.

Components of the ECG

The electrical events of the heart (ECG) are usually recorded as a pattern of a baseline (isoelectric line,) broken by a **P** wave, a **QRS** complex, and a **T** wave. In addition to the wave components of the ECG, there are intervals and segments (Fig. 5.2).

- The **isoelectric line** is a point of departure of the electrical activity of depolarizations and repolarizations of the cardiac cycles and indicates periods when the ECG electrodes did not detect electrical activity.
- An **interval** is a time measurement that includes waves and/or complexes.
- A **segment** is a time measurement that does not include waves and/or complexes.

Table 5.1 Components of the ECG & Typical Lead II Values*

ECG COMPONENT		*Measurement area…*	*Represent…*	Duration *(seconds)*	Amplitude (millivolts)
Waves	P	begin and end on isoelectric line (baseline); normally upright in standard limb leads	depolarization of the right and left atria.	0.07 – 0.18	< 0.25
	QRS complex	begin and end on isoelectric line (baseline) from start of Q wave to end of S wave	depolarization of the right and left ventricles. Atrial repolarization is also part of this segment, but the electrical signal for atrial repolarization is masked by the larger QRS complex (see Fig. 5.2)	0.06 – 0.12	0.10 – 1.50
	T	begin and end on isoelectric line (baseline)	repolarization of the right and left ventricles.	0.10 – 0.25	< 0.5
Intervals	P-R	from start of P wave to start of QRS complex	time from the onset of atrial depolarization to the onset of ventricular depolarization.	0.12-0.20	
	Q-T	from start of QRS complex to end of T wave	time from onset of ventricular depolarization to the end of ventricular repolarization. It represents the refractory period of the ventricles.	0.32-0.36	
	R-R	from peak of R wave to peak of succeeding R wave	time between two successive ventricular depolarizations.	0.80	
Segments	P-R	from end of P wave to start of QRS complex	time of impulse conduction from the AV node to the ventricular myocardium.	0.02 – 0.10	
	S-T	between end of S wave and start of T wave	period of time representing the early part of ventricular repolarization during which ventricles are more or less uniformly excited.	< 0.20	
	T-P	from end of T wave to start of successive P wave	time from the end of ventricular repolarization to the onset of atrial depolarization.	0.0 – 0.40	

* Notes: Tabled values represent results from a typical Lead II setup (wrist and ankle electrode placement) with Subject heart rate ~75 BPM. Values are influenced by heart rate and placement; values for torso placement would be different.

Leads

The particular arrangement of two electrodes (one **positive**, one **negative**) with respect to a third electrode (the **ground**) is called a **lead**. The electrode positions for the different leads have been standardized. For this lesson, you will record from **Lead II**, which has a positive electrode on the left ankle, a negative electrode on the right wrist, and the ground electrode on the right ankle. Typical Lead II values are shown in Table 5.1.

The dominant ECG component in any normal standard lead record is the QRS complex. Usually, in a Lead II record the Q and S waves are small and negative and the R wave is large and positive as shown in Fig. 5.2. However, it is important to note many factors, normal and abnormal, determine the duration, form, rate, and rhythm of the QRS complex.

- Normal factors include body size (BSA) and distribution of body fat, heart size (ventricular mass,) position of the heart in the chest relative to lead locations, metabolic rate, and others.

For example, in a person who has a high diaphragm, the apex of the heart may be shifted slightly upward and to the person's left. This change in the position of the heart alters the "electrical picture" of ventricular depolarization seen by the Lead II electrodes, resulting in decreased positivity of the R wave and increased negativity of the S wave. In other words, the positive amplitude of the R wave decreases and the negative amplitude of the S wave increases.

Similar changes in the Lead II QRS complex may be observed in a person, an athlete for example, who has no cardiac disease but does have a larger than normal left ventricular mass. In fact the decrease in R wave positivity coupled with the increase in S wave negativity may be so extreme as to give rise to the mistaken impression that the R wave has become inverted, when in reality the inverted spike is an enlarged S wave preceded by a much smaller but still positive R wave. When the amplitudes of Lead II Q, R, and S waves are all negative, the result is an abnormal inverted QRS complex.

- Abnormal factors include hyper- and hypothyroidism, ventricular hypertrophy (observed for example, in chronic valvular insufficiency,) morbid obesity, essential hypertension and many other pathologic states. A more detailed discussion of QRS changes in response to normal and abnormal factors requires an introduction to cardiac vectors, for which the reader is referred to Lesson 6.

Effects of the Resting Respiratory Cycle on Heart Rate

Temporary minor increases and decreases in heart rate associated with the resting respiratory cycle reflect heart rate adjustments made by systemic arterial and systemic venous pressure receptor (baroreceptor) reflexes in response to the cycling of intrathoracic pressure (Fig. 5.3).

When inspiratory muscles contract, pressure within the thorax (intrathoracic pressure) decreases, allowing thoracic veins to slightly expand. This causes a momentary drop in venous pressure, venous return, cardiac output, and systemic arterial blood pressure. The carotid sinus reflex normally decreases heart rate in response to a rise in carotid arterial blood pressure. However, the momentary drop in systemic arterial blood pressure during inspiration reduces the frequency of carotid baroreceptor firing, causing a momentary increase in heart rate.

When inspiratory muscles relax, resting expiration passively occurs. During early resting expiration, intrathoracic pressure increases causing compression of thoracic veins, momentarily increasing venous pressure and venous return. In response, systemic venous baroreceptors reflexively increase heart rate. However, the slight increase in heart rate is temporary because it increases cardiac output and systemic arterial blood pressure, which increases carotid baroreceptor firing causing heart rate to decrease.

Source: Richard Pflanzer, Ph.D., Associate Professor
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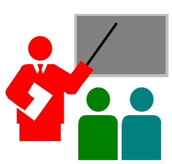
Fig. 5.3 Effects of the Resting Respiratory Cycle on Heart Rate



The average resting heart rate for adults is between 60-80 beats/min. (Average 70 bpm for males and 75 bpm for females.) Slower heart rates are typically found in individuals who regularly exercise. Athletes are able to pump enough blood to meet the demands of the body with resting heart rates as low as 50 beats/min. Athletes tend to develop larger hearts, especially the muscle in the left ventricle—a condition known as “left ventricular hypertrophy.” Because athletes (usually) have larger and more efficient hearts, their ECGs may exhibit differences other than average resting heart rate. For instance, low heart rate and hypertrophy exhibited in sedentary individuals can be an indication of failing hearts but these changes are “normal” for well trained athletes.

Because ECGs are widely used, basic elements have been standardized to simplify reading ECGs. ECGs have standardized grids of lighter, smaller squares and, superimposed on the first grid, a second grid of darker and larger squares (Fig. 5.4). The smaller grid always has time units of 0.04 seconds on the x-axis and the darker vertical lines are spaced 0.2 seconds apart. The horizontal lines represent amplitude in mV. The lighter horizontal lines are 0.1 mV apart and the darker grid lines represent 0.5 mV. In this lesson, you will record the ECG under four conditions.

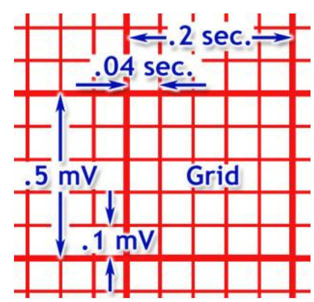


Fig. 5.4 standard ECG Grid

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II. EXPERIMENTAL OBJECTIVES

1) To become familiar with the electrocardiograph as a primary tool for evaluating electrical events within the heart.
2) To correlate electrical events as displayed on the ECG with the mechanical events that occur during the cardiac cycle.
3) To observe rate and rhythm changes in the ECG associated with body position and breathing.

III. MATERIALS

- BIOPAC Electrode Lead Set for MP41 (40EL)
- BIOPAC Disposable Electrodes (EL503), this lesson requires 3 electrodes
- Mat, cot or lab table and pillow for Supine position
- Biopac Student Lab System: BSL 4 software, MP41 hardware
- Computer System (Windows or Mac)
- Watch with second hand, stopwatch, or smartphone with timer

IV. EXPERIMENTAL METHODS

A. SETUP

FAST TRACK Setup

1. Set the MP41 dial to ◯ **OFF**.
2. **Plug the equipment in** as follows:
   - Electrode leads (40EL) → MP41
   - MP41 → computer USB port
3. Apply electrodes to clean skin (lotions, makeup and other skin products should be removed).
4. Attach three electrodes as shown in Fig. 5.6.

Setup continues…

Detailed Explanation of Setup Steps

Fig. 5.5 MP41 hardware connections

Remove any jewelry on or near the electrode sites. Apply electrodes to clean skin.

Place one electrode on the medial surface of each leg, just above the ankle. Place the third electrode on the right anterior forearm at the wrist (same side of arm as the palm of hand).

For optimal electrode contact, place electrodes on skin at least 5 minutes before start of Calibration.

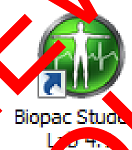
5. Clip the Electrode Lead Set (40EL) to the electrodes following the color code (Fig. 5.6).
6. RIGHT forearm = WHITE lead
7. RIGHT leg = BLACK lead (ground)
8. LEFT leg = RED lead

Fig. 5.6 Lead II Setup

The pinch connectors work like a small clothespin, but will only latch onto the nipple of the electrode from one side of the connector.

9. Start the BIOPAC Student Lab program.

Start Biopac Student Lab by double-clicking the Desktop shortcut.



10. Choose lesson "**L05 - Electrocardiography (ECG) I**" and click **OK**.
11. Type in a unique **filename** and click **OK**.

A folder will be created using the filename. This same filename can be used in other lessons to place your data in a common folder.

12. ***Optional***: Set Preferences.
    - Choose File > **Lesson Preferences**.
    - Select an option.
    - Select the desired setting and click **OK**.

This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:

Grids: Show or hide gridlines

Recording Length: Duration of recording can be set from 30 seconds to 30 minutes. 30 minutes is the default setting.

END OF SETUP

B. MP41 CHECK & SIGNAL CHECK

The MP41 **Check** and **Signal Check** establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimal performance. This check must be performed prior to running the lesson, with electrodes connected and the MP41 dial set to the specified position.

FAST TRACK Calibration

MP41 Check

1. Set the MP41 dial to ECG/EOG.
2. Press and hold the **Check** pad on the MP41.
3. Click Check MP41 when the light is flashing.
4. Wait for the MP41 check to stop.
5. Let go of the **Check** pad.
6. Click **Continue**.

Signal Check

1. Click Check Signal.
2. Wait for the Signal Check to stop (8 sec).
3. Review the data.
4. Verify recording resembles the example data.
    - If similar, click **Continue** and proceed to Data Recording.
    - If necessary, click Redo Signal Check.

END OF MP41 SIGNAL CHECK

Detailed Explanation of Calibration Steps

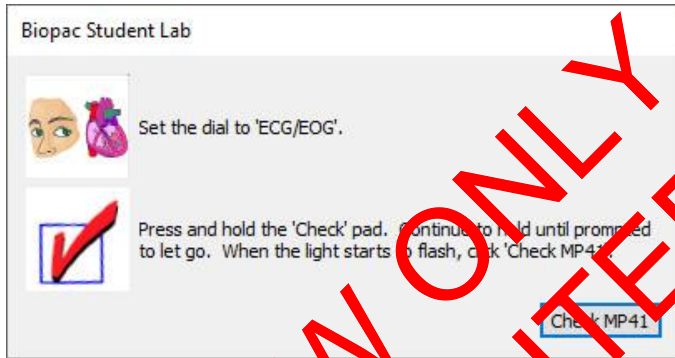


Figure 5.7 MP41 Check prompt

Continue to hold the pad down until prompted to let go.
The MP41 check procedure will last five seconds.
The light should stop flashing when the **Check** pad is released.
When the light stops flashing, click **Continue**.

The eight-second Signal Check recording should resemble Fig.5.8. There should be a recognizable ECG waveform with a baseline at or near 0 mV, little EMG artifact and no large baseline drift.

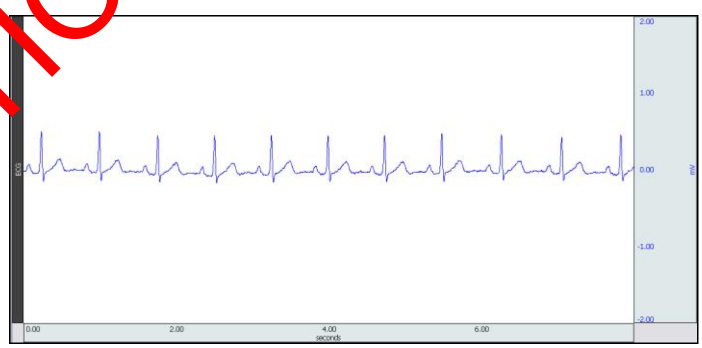


Fig. 5.8 Example Calibration data

If recording does not resemble the Example Data

- If the data is noisy or flatline, check all connections to the MP unit.
- If the ECG displays baseline drift or excessive EMG artifact:
    - Verify electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
    - Make sure **you are** in a relaxed position.

Click **Redo Signal Check** and repeat Steps 1 – 3 if necessary.

C. DATA RECORDING

FAST TRACK Recording

1. Prepare for the recording.
   - Review recording steps before proceeding.
   - Before clicking **Record**, set timer alarm on smartphone for 20 seconds.

Detailed Explanation of Recording Steps

You will record ECG under the following conditions:

- Supine (20 seconds)
- Seated (20 seconds)
- Deep breathing
- After exercise (60 seconds)

To work efficiently, read this entire section before recording, or review onscreen **Tasks** to preview recording steps in advance.

NOTE: This lesson works best if a second person assists the participant by inserting event markers and giving cues when each recording interval is completed. If no assistant is available, a solo participant keep track of the recording intervals by setting the timer function on a smartphone or other device prior to starting each recording.

Supine (Lying Down)

2. Get in supine position (lying down, face up) and relax (Fig. 5.9).

IMPORTANT: If recording this lesson alone, it is recommended that you place your computer within easy reach, so you can start and stop the recordings without changing positions.

Position the electrode cables so that they are not pulling on the electrodes.

Fig. 5.9 Positioning (supine)

3. Remain supine and relaxed, with eyes closed.
4. Start timer and click **Record**.
5. When the timer alarm sounds after 20 seconds, click **Suspend**.
6. Verify recording resembles the example data.
   - If similar, proceed to next recording.
   - If necessary, click **Redo**.
   - If all required recordings have been completed, click **Done**.

If performing lesson alone using a desktop computer, it will be necessary to click **Record** before getting into supine position and **Suspend** after getting up from supine position. In this case disregard the first and last 10 seconds of recorded data, as these portions will show movement artifact. Be sure to allow extra time to acquire at least 20 seconds of good uninterrupted supine data.

The ECG waveform should have a baseline at or near 0 mV and should not display large baseline drifts or significant EMG artifact. The Heart Rate (BPM) data will not be accurate until after the first two cardiac (ECG) cycles after which there should not be sporadic variations that go out of the visible range.

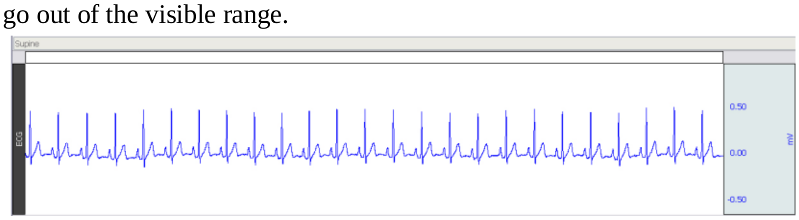


Fig. 5.10 Example Supine data

Recording continues…

<u>If recording does not resemble the Example Data</u>

- If the data is noisy or flatline, check all connections to the MP unit.
- If the ECG displays excessive baseline drift or EMG artifact, or if the Heart Rate (BPM) data shows sporadic values:
  - Verify electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
  - Make sure you are in a relaxed position.

Click **Redo** and repeat Steps 1 – 6 if necessary. Note that once **Redo** is clicked, the most recent recording will be erased.

Seated

- **Review** recording steps.
- **Watch** example video in software.

7. Before clicking **Resume**, set timer alarm on smartphone for 20 seconds.
8. Get up quickly and then settle into a seated position (Fig. 5.11).

> **IMPORTANT:** If recording this lesson alone, place the computer within easy reach so you can click **Record** immediately after getting into seated position.

Sit with arms relaxed at side of body and hands apart in lap, with legs flexed at knee and feet supported for seconds 21 – 40.

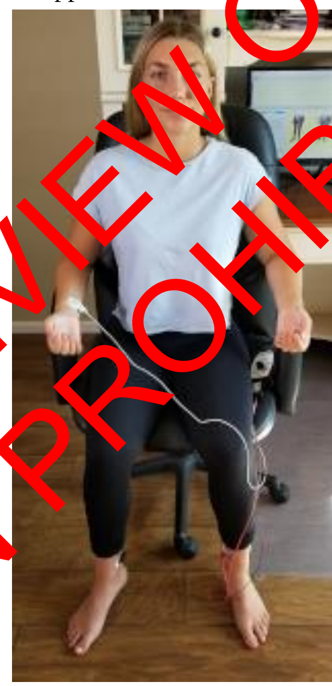


Fig. 5.11 Positioning (seated)

9. Once you are seated and still, start the timer and click **Resume**.

In order to capture the heart rate variation, click **Record** as quickly as possible after sitting down.

Remain seated, relaxed, and breathing normally.

10. When the timer alarm sounds after 20 seconds, click **Suspend**.
11. Verify recording resembles the example data.
    - If <u>similar</u>, proceed to the next recording.

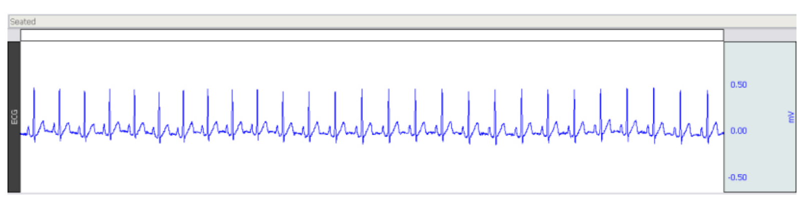


Fig. 5.12 Example Seated data

- If necessary, click **Redo**.
- If all required recordings have been completed, click **Done**.

The data description is the same as outlined in Step 6.

Click **Redo** if necessary. You must return to the Supine position for at least 5 minutes before repeating Steps 7 – 11.

Note that once **Redo** is clicked, the most recent recording will be erased.

Recording continues…

Deep Breathing

- **Review** recording steps.

Remain seated for this recording.

12. Click **Resume**.
13. Inhale and exhale slowly and completely as possible for five prolonged (slow) breath cycles.
    - Press F9 (Windows) or esc (Mac) at the start of each inhale and at start of each exhale.

Note It is important to breathe with long, slow, deep breaths to help minimize EMG artifact.

Label the keystroke (**F9** Windows, **esc** Mac) event markers "**Inhale**" and "**Exhale**." To label an event marker during or after the recording, click the marker to select it and enter text in the marker label region above the graph.

14. Click **Suspend**.
15. Verify recording resembles the example data.
    - If similar, proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Fig. 5.13 Example Deep Breathing data

The data description is the same as outlined in Step 6 with the following exception:

- The ECG data may exhibit some baseline drift during deep breathing which is normal and unless excessive, does not necessitate **Redo**.

Click **Redo** and repeat Steps 12 – 15 if necessary. Note that once **Redo** is clicked, the most recent recording will be erased.

After exercise

- **Review** recording steps.
- **Watch** example video in software.

Perform an exercise to elevate your heart rate fairly rapidly, such as running up stairs, push-ups, or jumping-jacks.

16. Before clicking **Resume**, set timer alarm on smartphone for 60 seconds.
17. Exercise to elevate heart rate.
    - If electrode leads were unclipped, clip them back on.
    - Following exercise, sit down and relax.

Note You may remove the electrode cable pinch connectors so that you can move freely, but **do not remove the electrodes**.
If you do remove the cable pinch connectors, you must reattach them following the precise color placement in Fig. 5.6 prior to clicking **Resume**.

When seated, your arms must be relaxed and at sides of body, with arms relaxed and feet supported.

In order to capture the heart rate variation, it is important that you resume recording as quickly as possible after performing the exercise. However, it is also important that you do not click **Resume** while exercising, or you will capture motion artifact.

18. Once you are seated and still, start the timer and click **Resume**.
19. When the timer alarm sounds after 60 seconds, click **Suspend**.
20. Verify recording resembles the example data.
    - If similar, proceed to optional recording section, or click **Done** if finished.
    - If necessary, click **Redo**.

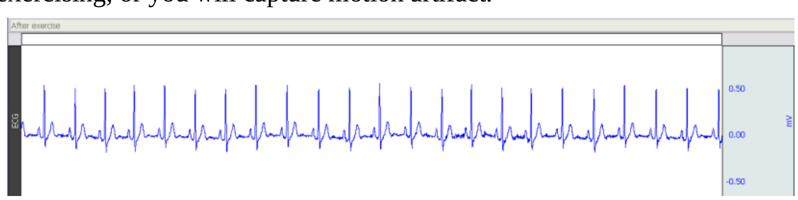


Fig. 5.14 Example After Exercise data

The data description is the same as outlined in Step 6, with the following exception:

- The ECG data may exhibit some baseline drift which is normal and unless excessive, does not necessitate **Redo**.
- Click **Redo** and repeat Steps 16 – 20 if necessary. Note that once **Redo** is clicked, the most recent recording will be erased.

Recording continues…

OPTIONAL ACTIVE LEARNING PORTION

With this lesson you may record additional data segments by clicking **Resume** following the last recording segment. Design an experiment to test or verify a scientific principle(s) related to topics covered in this lesson. Although you are limited to this lesson's channel assignments, the electrodes-may be moved to different physical locations.

Design Your Experiment

Use a separate sheet to detail your experiment design, and be sure to address these main points:

A. ***Hypothesis***

Describe the scientific principle to be tested or verified.

B. ***Materials***

List the materials you will use to complete your investigation.

C. ***Method***

Describe the experimental procedure—be sure to number each step to make it easy to follow during recording.

Run Your Experiment

D. ***Set Up***

Set up the equipment and prepare for your experiment.

E. ***Record***

Use the **Resume** and **Suspend** buttons to record as many segments as necessary for your experiment.
Click **Done** when you have completed all of the segments required for your experiment.

Analyze Your Experiment

F. Set measurements relevant to your experiment and record the results in a Data Report.

21. After clicking **Done**, choose an option and click **OK**.

If choosing the **Record from another Subject** option:

- Repeat Setup Steps 6 – 9, and then proceed to Signal Check.

22. Remove the electrodes.

Remove the electrode cable pinch connectors and peel off all electrodes. Discard the electrodes. (BIOPAC electrodes are not reusable.) Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours which is quite normal.

END OF RECORDING

V. DATA ANALYSIS

In this section, you will examine ECG components of cardiac cycles and measure amplitudes (mV) and durations (msecs) of the ECG components.

***Note**:* Interpreting ECGs is a skill that requires practice to distinguish between normal variation and those arising from medical conditions. Do not be alarmed if your ECG is different than the normal values and references in the Introduction.

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode.

- Note Channel Number (CH) designation:

CH 1	**ECG Raw** (hidden)
CH 2	**Heart Rate**
CH 40	**ECG**

- Set the measurement boxes as follows:

Channel	*Measurement*
CH 2	**Value**
CH 40	**Delta T**
CH 40	**P-P**
CH 40	**BPM**

Note Measurements will be taken on the ECG channel. To see the average heart rate, select an area and measure Mean on CH 2, Rate.

Data Analysis continues…

Detailed Explanation of Data Analysis Steps

If entering **Review Saved Data** mode from the Startup dialog or lessons menu, make sure to choose the correct file.

Fig. 5.15 Example data

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click them.

Brief definition of measurements:

Value: Displays the amplitude value at the point selected by the I-beam cursor. If an area is selected, displays the value of the endpoint based on the direction the cursor was dragged.

- CH 2 heart rate data is only updated at the end of an R-R interval so it remains constant within an R-R interval; therefore, the Value (BPM) measurement will be accurate from any selected point in the R-R interval.
- Single point Values will be shown when placing the Arrow cursor over the data while holding down the left mouse button.

Delta T: Displays the amount of time in the selected area (the difference in time between the endpoints of the selected area).

P-P (Peak-to-Peak)**:** Subtracts the minimum value from the maximum value found in the selected area.

BPM: **B**eats **P**er **M**inute measurement first calculates the difference in time between the beginning and end of the selected area (seconds/beat,) and divides this value into 60 seconds/minute.

The "selected area" is the area selected by the **I-beam** tool (including endpoints).

Textual notes (such as identifying components of the ECG wave) can be inserted into the graph by using the **Annotation** tool. This tool will place a small editable text box anywhere in the waveform.

2. Set up your display window for optimal viewing of three complete cardiac cycles from the initial "**Supine**" segment.

NOTE: For accurate BPM data go past the first two cardiac cycles.

Fig. 5.16 Zoom in on "Supine" data

Note: The append event markers ◆ mark the beginning of each recording. Click (activate) the event marker to display its label.

Useful tools for changing view:

Display menu: Autoscale Horizontal, Autoscale Waveforms, Zoom Back, Zoom Forward

Scroll Bars: Time (Horizontal), Amplitude (Vertical)

Cursor Tools: Zoom Tool

Buttons: Overlap, Split, Adjust Baseline (Up, Down,) Show Grid, Hide Grid, Copy Graph, -, +

Hide/Show Channel: "Alt + click" (Windows) or "Option + click" (Mac) the channel number box to toggle channel display.

The Heart Rate channel is updated at the end of each R-R interval, so it will initially appear "out of sync," or delayed by one interval. (See Fig. 5.18 for illustration.)

Fig. 5.17 Overlap sample: Heart Rate and ECG after supine subject is seated

Adjust Baseline allows you to position the waveform up or down in small increments so that the baseline (isoelectric line) can be exactly zero. After **Adjust Baseline** is pressed, **Up** and **Down** buttons are generated. Simply click these to move the waveform up or down. This is not needed to get accurate amplitude measurements, but may be desired before making a printout, or when using grids.

3. For measuring heart rate, use the cursor to select any data point within an R-R interval.

A

Note that the CH 2 Value measurement displays the BPM for the interval preceding the current R-R interval.

Follow the examples shown above to complete all the measurements required for the Data Report.

4. Take measurements within two other R-R intervals in the current segment.

A

5. Repeat measurements on the other segments as required for the Data Report.

A

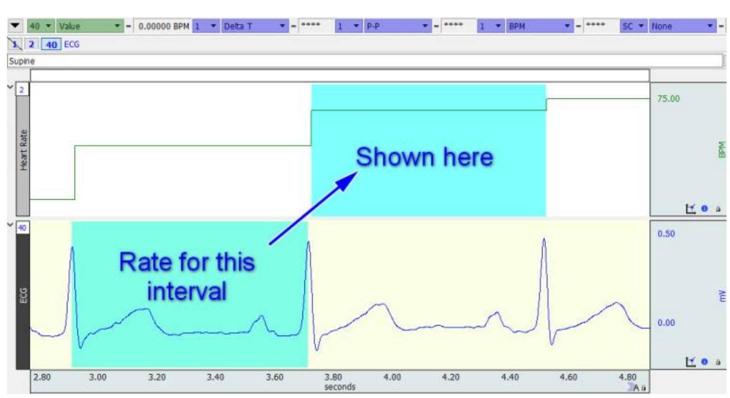


Fig. 5.18 Data point selection for Heart Rate data correlated to ECG data

Data Analysis continues…

6. Hide CH 2.

The remaining measurements use ECG data only. To hide Heart Rate data display and focus on ECG data, Alt + click (Windows) or Option + click (Mac) the "2" channel number box.

7. **Zoom** in on a single cardiac cycle from "**Supine**" segment.
8. Measure Ventricular Systole and Diastole.

B

For Ventricular Systole and Diastole measurements, the T wave reference point for the selected area is 1/3 of the way down the descending portion of the T wave; if necessary, see Fig. 5.2 and Table 5.1 in the Introduction PDF for selected area details.

9. Repeat measurements for "**After exercise**" segment.

B

Measurement data starts at the append event marker labeled "**After exercise**."

10. **Zoom** in on a single cardiac cycle from "**Supine**" segment.
11. Use the I-Beam cursor to select segments and measure the durations and wave amplitudes required for the Data Report. Use P-P measurement to obtain amplitudes.

C

Select the components of the ECG as specified in the Introduction and gather wave amplitude data for 3 cycles using the P-P measurement. If necessary, see Fig. 5.2 and Table 5.1 in the Introduction for selected area details.

Fig. 5.19 Measuring P wave duration (Delta T) and amplitude (P-P)

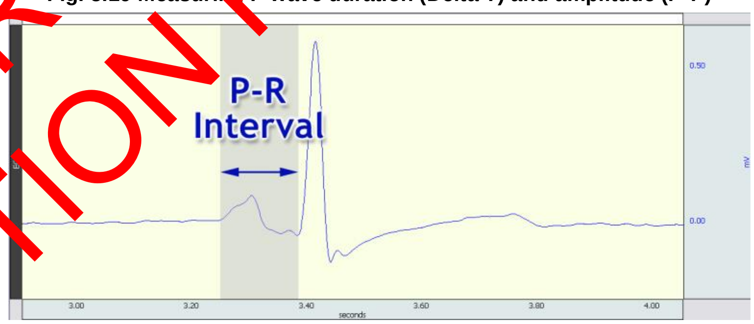


Fig. 5.20 Selection of P-R Interval

Follow the examples shown above to complete all the measurements required for your Data Report.

12. **Zoom** in on a single cardiac cycle from "**After exercise**" segment.
13. Repeat duration and amplitude (P-P) measurements using "**After exercise**" data as required for the Data Report.

C

Data Analysis continues…

14. **OPTIONAL:** Using the **Annotation** tool, insert text boxes identifying the ECG components in the selected area. Copy and paste this graph to the Data Report at the end of Section C.

Use the **Annotation** Tool to insert text boxes into the graph identifying the ECG components in the selected portion, and then drag them to their correct locations within the ECG waveform.

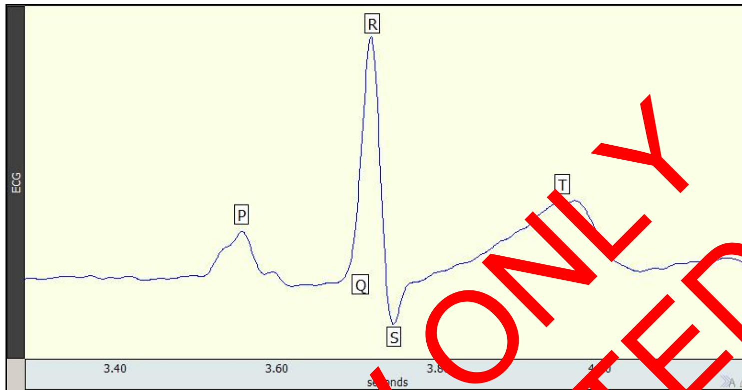


Fig 5.21 Example of ECG Component Annotations

- Use the **Copy Graph** button to copy the selected area.
- Use the contextual menu in the Journal to paste the graph into the Data Report.

15. Answer the questions at the end of the Data Report.

Complete the **Data Report** immediately following this Data Analysis section. You may save the data, save notes that are in the journal, or print the data file.

16. **Save** or **Print** the data file.
17. **Quit** the program.
18. Set the MP41 dial to **Off**.

END OF DATA ANALYSIS

END OF LESSON 5

Complete the Lesson 5 Data Report that follows.

ELECTROCARDIOGRAPHY I

- *ECG I*

DATA REPORT

Student's Name: ____
Lab Section: ____
Date: ____

I. Data and Calculations

Subject Profile

Name:____ Height:______________

Age:____________ Gender: Male / Female Weight:______________

A. Heart Rate

Complete the following tables with the lesson data indicated, and calculate the Mean as appropriate.

Table 5.2

Recording: Condition	Cardiac Cycle 1	2	3	Mean (calculate)
Supine				
Seated				
Start of inhale				
Start of exhale				
After exercise				

B. Ventricular Systole and Diastole

Table 5.3

Condition	Duration (ms) 40 Delta T	
	Ventricular Systole	Ventricular Diastole
Supine		
After exercise		

C. Components of the ECG

Table 5.4

Condition: Supine Recording (measurements taken from 3 cardiac cycles)										
ECG Component	Normative Values Based on resting heart rate 75 BPM		Duration (ms) 40 Delta T				Amplitude (mV) 40 P-P			
			1	2	3	Mean (calc)	1	2	3	Mean (calc)
Waves	Dur. (sec)	Amp. (mV)								
P	.07 - .18	< .2[illegible]								
QRS Complex	.06 - .12	[illegible] – 1.5								
T	.10 - .25	< [illegible]								
Intervals	Duration (seconds)									
P-R	.12 - .2[illegible]									
Q-T	.32 - .36									
R-R	.80									
Segments	Duration (seconds)									
P-R	.0[illegible] - .10									
S-T	[illegible] .20									
T-P	0 - .40									

Table 5.5

Condition: After Exercise Recording (measurements taken from 1 cardiac cycle)

ECG Component	Normative Values Based on resting heart rate 75 BPM		Duration (ms) 40 Delta T	Amplitude (mV) 40 P-P
Waves	Dur. (sec)	Amp. (mV)		
P	.07 - .18	< .20		
QRS Complex	.06 - .12	.10 – 1.5		
T	.10 - .25	< .5		
Intervals	Duration (seconds)			
P-R	.12 - .20			
Q-T	.32 - .36			
R-R	.80			
Segments	Duration (seconds)			
P-R	.02 - .10			
S-T	< .20			
T-P	0 - .40			

Note Interpreting ECGs is a skill that requires practice to distinguish between normal variations and those arising from medical conditions. Do not be alarmed if your ECG does not match the "Normative Values."

II. Questions

D. Using data from table 5.2:

1) Explain the changes in heart rate between conditions. Describe the physiological mechanisms causing these changes.

____

____

____

____

____

____

____

____

____

2) Are there differences in the cardiac cycle with the respiratory cycle ("Start of inhale-exhale" data)?

____

____

____

____

E. Using data from table 5.3:

1) What changes occurred in the duration of systole and diastole between resting and post-exercise?

____

____

____

____

F. Using data from tables 5.4 and 5.5:

1) Compared to the resting state, do the durations of the ECG intervals and segments decrease during exercise? Explain ____

____

2) Compare your ECG data to the normative values. Explain any differences. ______________________

____

3) Compare ECG data with other groups in your laboratory. Does the data differ? Explain why this may not be unusual. ____

____

G. In order to beat, the heart needs three types of cells. Describe the cells and their function.

1) ______________________________
2) ______________________________
3) ______________________________

H. List in proper sequence, starting with the normal pacemaker, elements of the cardiac conduction system.

1) ______________
2) ______________
3) ______________
4) ______________
5) ______________
6) ______________
7) ______________
8) ______________

I. Describe three cardiac effects of increased sympathetic activity, and of increased parasympathetic activity.

Sympathetic ______________________________

____

____

Parasympathetic ______________________________

____

____

J. In the normal cardiac cycle, the atria contract before the ventricles. Where is this fact represented in the ECG?

____

____

K. What is meant by "AV delay" and what purpose does the delay serve?

____

____

L. What is the isoelectric line of the ECG?

____

____

M. Which components of the ECG are normally measured along the isoelectric line?

____

____

III. OPTIONAL Active Learning Portion

A. ***Hypothesis***

B. ***Materials***

C. ***Method***

D. ***Set Up***

E. ***Experimental Results***

End of Lesson 5 Data Report